A Discourse on the Coase Theorem

Kwang Choi*

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Commentator: Suppose the person next door is driving me into a frenzy by incessantly working his new motorized lawn mower, or his new motorized hedgetrimmer, or his new soil-turner, or something new and motorized, what can I do to preserve my sanity?

Pangloss: Why, you can bribe him to stop, or to fit silencers to his motors.

Commentator: But is that fair?

Pangloss: Perfectly fair. Why should you interfere with his enjoyment without compensating him? Besides which, if you can bribe him to stop, both he and you are made better off than before. Such a solution is clearly ideal.

Commentator: But suppose I cannot afford to bribe him?

Pangloss: Why, in that case the exiting situation is already ideal or—as we economists say—'optimal.'

——E.J. Mishan

I. Introduction

In an article entitled "The Problem of Social Cost" R. Coase [8] conceived a revolution in economics. The ideas and directions of the past were thrown out by Coase as being too arbitrary; his job, he felt, was to innovate, to describe new ideas and directions, to provide a new approach to a problem which most economists felt was already solved. Coase's paper was concerned with harmful effects of many economic actions undertaken by producers and consum-

*The author is Research Fellow, Korea Development Institute.

ers on others, what we today call externalities.[1]

The predominant theory regarding effects of externalities on the resource allocation stems from A.C. Pigou, and the typical Pigovian conclusion is that independent market adjustments always lead to a less or more than Pareto optimal supply of goods or services when there exist externalities. The Pigovian policy prescription allows that collective action in the form of taxes or bounties is necessary to discourage or encourage externality generating activities.

Coase does not agree that the tax-subsidy scheme is the only solution and his ideas, later known as the Coase theorem, are presented as an alternative approach to the allocation of resources when an externality exists. In a nutshell, the Coase theorem says that given the initial delimitation of rights in a situation in which an externality exists, the allocation of resources which will result will be an efficient solution regardless of which party was assigned the rights, if the pricing system is assumed to work without cost. This approach is totally unlike its predecessor in that it does not arbitrarily assume that government action is necessary to bring about a desirable solution.

The theorem seems to have formed the intellectual basis for many attacks upon the economists' conventional wisdom regarding the allocative consequences of harmful effects and, more specifically, the necessity and/or desirability of collective intervention in markets where such effects are present. Though Coase's seminal work on social costs has rightly had an enormous impact on the profession, controversies still shroud many of the issues raised.

The purpose of this paper is twofold. One is to show what is original and new in Coase's work, and the other is to examine the validity and implications of the Coase theorem in depth. We shall begin, in Section II, with a discussion of the meaning of externality and the effects of externality on resource allocation. Section III provides a thorough review of the Coase theorem by way of verbal and numerical examples as well as a diagrammatic

(1) It may be noted in passing that Coase never mentioned the word externality in his article.

presentation. In Section IV controversies surrounding the validity of the theory and the practicality of the theorem in the real world is analyzed using the major themes of the contrasting arguments. Finally, Section V concludes the discussion by summarizing the contributions and implications of the Coase theorem.

II. The Meaning and the Effects of Externality

Externalities have been a part of economic theory since they were first discussed by A. Marshall.(2) The attention given to externalities in recent literature is fully justified by the unfortunate albeit inescapable fact that as societies grow in material wealth the incidence of the external effects grow rapidly.

External effect or externality is in some ways a straightforward concept; yet in others it is extraordinarily elusive.

At first glance, the distinction between an internal effect and an external effect in the analysis of economic activities seems clear and straightforward. I hire a carpenter to mend my table. The service I get from having my table mended and the benefit he receives from the wage which I pay him are all internal to the transaction which takes places between the carpenter and me. But suppose that his hammering disturbs my neighbor's enjoyment of snooze he is taking in his garden. This effect is external to the transaction between the carpenter and myself, who together take the decision to mend the table. The noise annoyes someone who is outside or external to our decision and takes no part in reaching it.

In our economic activities, there are harmful or beneficial side effects that are borne by people who are not directly involved in market exchanges. These side effects of ordinary economic activities are called externalities because their

(2) The externalities described by Marshall is later classified as pecuniary, inasmuch as they produce changes in prices of goods and services which are taken into account by other buyers and sellers. Our discussion in this paper deals with technological rather than pecuniary externalities.

effects are outside or external to the price system. Whenever someone inflicts a harm on another person without compensating him or aids him without being compensated, there exists an externality.

Different writers have adopted different definitions of externalities.A glimpse of definitions of externalities adopted by some economists will help to understand the nature and characteristics of externalities and to further our discussion in the following.

In Pigou's classic discussion [36], externalities are defined to arise where:

"one person A, in the course of rendering some services, for which payment is made, to a person B, incidently also renders services or disservices to other persons.... of such a sort that payment cannot be exacted from the benefited parties or compensation enforced on behalf of the injured parties." (p. 183)

J.E. Meade [27] adopts the following definition:

"An external economy (diseconomy) is an event which confers an appreciable benefit (inflicts an appreciable damage) on some person or persons who are not fully consenting parties in reaching the decision or decisions which led directly or indirectly to the event in question." (p. 3)

William J. Baumol and Wallace E. Oates [4] suggest that for a relationship to qualify as an externality it must satisfy two requirements:

Condition 1. "An externality is present whenever some individual's (say A's) utility or production relationships include real (that is, nonmonetary) variables, whose values are chosen by others (persons, corporations, governments) without particular attention to the effects on A's welfare." (p. 17)
Condition 2. "The decision maker, whose activity affects others' utility levels or enters their production functions, does not receive (pay) in compensation for this activity an amount equal in value to the resulting (marginal) benefits or costs to others." (p. 18)

W.P. Heller and D.S. Starrett [22] define an externality to be:

"a situation in which the private economy lacks sufficient incentives to create a potential market in some good and the nonexistence of this market results in losses in Pareto

efficiency." (p. 10)

Heller and Starrett argue that situations usually identified with externality have more fundamental explanations in terms of (1) difficulties in defining property, (2) noncompetitive behavior, (3) absence of relevant economic information, or (4) nonconvexities in transactions costs. To Heller and Starrett externalities are nearly synonymous with the nonexistence of market.

Buchanan and Stubblebine [7] seek to clarify the ideas of externality by providing a rigorous definition. What they come up with are three sets of definitions. The first set of definitions includes marginal externalities and infra-marginal externalities. Marginal externalities exist when a small change in the actions of the externality producer affects the choices of action faced by the externality recipient. An infra-marginal externality exists when small changes in the externality producer's action produce no effects on the recipient, though, as a whole, the action does affect the recipient.

The second set of definitions defines potentially relevant and potentially irrelevant externalities. An externality is potentially relevant if the activity, to the extent it is being performed, produces a desire on the part of the recipient of the externality to modify the behavior of the externality producer. The last group of definitions includes Pareto relevant and irrelevant externalities. An externality is Pareto relevant if by a modification of the externality producer's action, the recipient can be made better off without harming the producer.

The concept Buchanan and Stubblebine call the "Pareto-relevant externality" corresponds to what is meant in most of the literature when the term "externality" is used without modifiers. By and large, Buchanan and Stubblebine define externalities not in terms of what they are but what they do. The Pareto relevant type of externality is the class of external effects that Coase was interested in. Pareto-relevant externalities are characterized by "gain from trade," which was exactly what Coase was advocating, trade between the externality producer and recipient.

Definitions are a matter of taste and convenience. However, what is common in the definitions examined above is that two conditions are required for the existence of an externality: (1) interdependence between economic units and (2) non-compensation for the effects of interdependence. Externality is not the same as economic interdependence. When I rely on the farmer for my food, no externality need be involved, for he does not decide for me how much rice I will consume, nor does my consumption enter directly into his utility function. The second proviso of non-compensation is required if the externality is to have all of the unpleasant consequences, including inefficiencies and resource misallocation.

What are causes of externality? Fundamentally, externality exists due to a lack of enforcement of property rights either because exclusion is not possible or because property right has not been assigned or cannot be assigned without great difficulty.(3) For example, party A and B both have access to the use of the atmosphere. Party A pollutes the air that party B uses without any account being taken of the damage done. If one or the other party could be assigned ownership rights to their share of the atmosphere and could exclude the other from its use, the externality could be internalized. A would be forced to take the price of the air into account in deciding how much use to make of it.

Externalities exist because of costs. Pricing or transaction costs are a convenient sobriquet for a multifarious category of costs which include (1) information costs, (2) negotiating costs, (3) exclusion costs, and (4) revenue collection costs. A difficulty with the usual definition of externality is the lack of clarity concerning which costs give rise to the phenomenon.

There are the difference and the similarity between a public good and a good generating external benefits. Both have the joint consumption property. The same commodity or activity enters the utility functions of several persons or production functions of several firms simultaneously. Analytically, a very close relationship is confirmed by a formal expression of the necessary optimal con-

(3) This is the point found in Coase [8].

dition, $\sum MB = MC$. There is no purely formal differences so far as necessary and sufficient conditions for top-level optimality for both externalities and public goods. If there is any difference between externalities and public goods it may be the fact that externalities arise as an unintended byproduct of activities undertaken by individual or firm purposes. The private benefit to the individual is relatively large compared to the external benefits generated, large enough to provide enough incentives for individuals or firms to undertake the activity in the first place. With public goods, on the other hand, the benefits to any single individual would be relatively small compared with the cost of providing the services of the good, so that individuals might not voluntarily provide any of it for themselves.

The distribution of the benefits from consuming a good with external benefits is usually very skewed. A may receive some benefits from B's becoming better educated, but clearly the benefit B receives is many times greater. Public goods tend to benefit people more equally. The term externality refers to positive or negative effect that is incidental to the activity in question. In contrast the effects of a public good on people's welfare are in the first instance at least wholly intentional. This difference accounts for the fact that the typical remedy for market failure due to public goods is for the public sector to provide the goods while the standard remedy for externalities is often to provide incentives to the private sector to produce the correct amount.

To see how externalities affect the efficiency of market allocation, let us consider a case in which the production of a commodity, say iron, generates air pollution that adversely affects the welfare of the people in the surrounding community. The cost of iron thus has two components: (1) the cost of the labor, machines, iron ore, coal, and other inputs directly required to produce the iron; and (2) the costs borne by members of the community in the form of air pollution damages.

In Figure 1 the marginal cost (*MC*) schedule shows how the first category of costs varies as the output of iron varies. The social marginal cost (*SMC*)

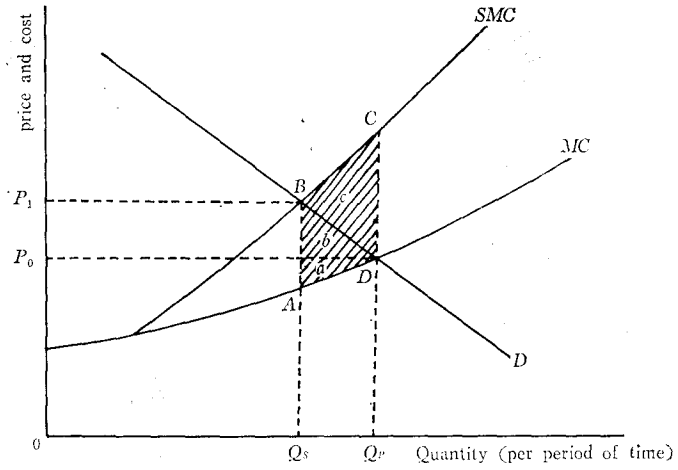


Figure 1

schedule shows the additional costs, both direct and air pollution costs, associated with additional units of output. The vertical difference between the two schedules represents the pollution damages associated with each unit of iron production. Pollution damages are defined as the amounts that all persons affected by the pollution would pay to eliminate the pollution. For example, the shaded area of Figure 1 represents the amount that those damaged by pollution would pay to have pollution reduced from the level associated with iron output of Q_p to the lower pollution level associated with Q_s.

The market demand schedule for iron is D. Given these demand and cost schedules, firms will produce Q_p units to be sold at price P_o if (1) markets are competitive, (2) pollution is legal, (3) firms do not have to compensate anyone damaged by the air pollution, and (4) those damaged by pollution do not bribe firms to produce less. Under these assumptions, the competitive market equilibrium price and quantity are P_o and Q_p respectively. The market is in equilibrium at P_o and Q_p because to the left of Q_p price exceeds private marginal cost; competitive suppliers will increase output in an attempt to capture the profit represented by the excess of price over marginal cost. On the other hand, if output exceeds Q_p units, then marginal cost exceeds price; suppliers will reduce output because a loss is incurred on each unit produced in excess of Q_p.

However, the competitive equilibrium output level, Q_p is not an efficient outcome from the society's point of view because non-polluters suffer losses at the margin equal to CQ_p, while polluters reap gains, equal to DQ_p. For all levels from Q_p to Q_s, it is clear that losses exceed gains and that the private solution is inefficient. The efficient output corresponds to the level of production where social marginal cost is equal to the price of output. This occurs at point B, where the output of iron is Q_s. When externalities exist, benefits or costs facing private individuals in the market differ from true social costs or benefits.

III. The Coase Theorem

1. Verbal Statement

In his paper Coase [8] focuses on the action of business that produce harmful effects on others. Prior to his article the analysis of such situation tended to dwell upon a divergence between the private and social product of the business. The conclusion from this type of analysis is that collective action should be taken to impose liability on the damaging business for the damage it causes. Coase does not agree; he says that the old approach tends to obscure the fact that these externalities are reciprocal in nature. Suppose A is harmed by B, then the old approach would have asked how B should be restrained. With the new approach the question becomes, should B be allowed to harm A or should A be allowed to harm B by imposing liability on him for his damage? Both parties cause the damage, one by producing it and the other by being in the position to receive it. Therefore, to attain an optimal allocation of resources it is necessary that both parties take the harmful effect into account in deciding on their course of action.

Coase [8] states his new ideas like this:

"It is necessary to know whether the damaging business is liable or not for damages caused since without the establishment of this initial delimitation of rights there can be no market transactions to transfer and recombine them. But the ultimate result (which

maximizes the value of production) is independent of the legal position if the pricing system is assumed to work without cost." (p. 7)

The Coase theorem, without violence to common usage, may be expressed as:

Ignoring the income distribution effects, voluntary bargaining can lead to efficient allocational outcomes even when externalities exist provided that the initial legal assignment of property rights is well-defined and the transactions involved are costless. This results hold true regardless of the assignment of the property right to the parties involved, so long as the property right is clearly defined.

The thrust of the Coase theorem is that the invisible hand is much more effective than the argument about externalities at first suggests. For there are natural market forces at work tending to bribe the external effects into the calculations of the responsible parties. If a producer initially owns the right to generate a harmful externality, those adversely affected can offer him a financial reward for not exercising that right. Or if the other parties are initially entitled to be safe from the externality, it is up to the producer to offer terms of compensation at which they will accept a degree of harm. So long as the legal rights are well-defined and marketable, the invisible hand will tend to lead the parties to an efficient outcome, i.e., to a result that exhausts all possibilities for further mutual gain.

Perhaps Coase's most important contribution was to point out that externalities are bilateral. When smoke from a mill bothers nearby residents, the mill imposes external costs on them. But if laws are enacted to reduce the output of smoke, the neighbors impose external costs on the nearby mill.

Two claims are made by the Coase theorem: first, voluntary two-party bargaining in a zero transaction cost would result in optimal allocation—the efficiency claim, and second, the outcome of the bargaining process is invariant with respect to the structure of property right—the invariance (or neutrality) claim.

When the operation of the pricing is without cost, externalities do not impede the attainment of an efficient allocation of resources. This efficiency claim

is based on the logic that the potential gains from trade will generate the incentives for individuals to continue trading until all inefficiencies in the economy have been removed.

Using Figure 1, we can show as follows how the attainment of socially optimum level of output, Q_s, is done. Although an output of Q_p is the competitive market equilibrium, there is a potential welfare gain for all persons to be obtained by reducing output. To see why, note that the air pollution cost associated with the Q_p unit of output is the distance CD. Those damaged by pollution would be better off if they were to pay any amount less than CD to producers to induce them not to produce the Q_p unit. Any such payment would also make the producers better off since they earn zero profit on the Q_p unit. Therefore there is a potential welfare gain for all parties if the Q_p unit is not produced. A similar argument holds for all units in the range Q_s to Q_p, where the pollution damages per unit exceed producer and consumer surplus per unit; those who are damaged by pollution would gain enough from reducing the output to more than compensate the producers and consumers of iron for the reduced output. If output is reduced from Q_p to Q_s, pollution damages fall by the amount represented by the area $a+b+c$. Producer and consumer surplus fall by areas a and b, respectively. The potential net welfare gain is thus the area c.

We can state this conclusion differently. At the competitive equilibrium output of Q_p, the social marginal cost of iron—the cost that an additional unit of iron production imposes on all members of society—exceeds the marginal value of iron (the price of iron) to iron users because the air pollution costs are external to and therefore ignored by producers in their output decisions. And this is true for all outputs in excess of Q_s. Therefore, if output is reduced to Q_s, there is a potential gain that could be distributed so as to increase the welfare of all members of society. Reducing output below Q_s cannot increase the welfare of all persons (both those damaged by pollution and the producers and consumers of iron) because the reduction in pollution damages is less than

the fall in producer and consumer surplus. That is, although iron production continues to generate external costs when output is limited to Q_s, such external costs are not Pareto relevant because their elimination must make some one worse off.

The logic underlying the liability neutrality theorem is based on the concept of opportunity cost that "a receipt forgone of a given amount is the equivalent of a payment of the same amount."(4) If the bargaining is assumed to be co-operative, then the opportunity cost of the harm will be reflected in the injurer's costs of production irrespective of the law, either as an explicit compensation payment or an implicit cost in terms of a forgone bribe from the victim. Coase argues that although different legal rules will alter the relative income of the parties involved, the allocation of resources would not be influenced.

2. Numerical Illustration

Perhaps one of Coase's original examples will help to clarify the new ideas proposed by Coase. Suppose there is a cattle-raiser and farmer on adjoining property and that the cattle occasionally stray into the wheat field of the farmer, thus damaging crops. We will assume and reasonably so, that as the size of the cattle herd increases the amount of crop damage increases. Thus, an increase in the supply of cattle may be obtained only at the cost of a decrease in the supply of wheat.

Assume that the law is such as to require the cattle producer to pay for all damages to the wheat farmer. The relationship between the number of cattle in the herd and the profits with and without taking into account the value of crop damage is given in Table 1.

In the absence of any damage inflicted on the wheat farm, the cattleman will choose to have a herd of 4 cattle because four is the number of cattle that maximizes his profits, as shown in the second column of Table 1. Since the cattle-raiser is liable for damage caused by his steers, he will take into account the marginal crop loss and its associated marginal cost to him when

(4) Coase [8, p. 7].

Table 1

Size of cattle herd	Annual profits based on private cost	Annual value of damage to wheat farmer	Annual profits based on social costs
1	100	10	90
2	150	15	135
3	175	30	145*
4	185*	45	140
5	180	55	125
6	175	70	105

*Maximum profits.

making decisions about optimal herd size along with the regular marginal costs of increasing the size of his herd. The new profit schedule in the last column of Table 1 is computed on the basis of full social costs, and is obtained simply by deducting damages paid by the cattleman to the wheat farmer at each level of output for cattle production. After this calculation is performed, maximum profits now call for a herd of 3 rather than 4 cattle.

It might be argued that, since the cattle-raiser must pay for damages caused by his cattle, the farmer would plant more in crops than was profitable, in order to extract a higher damage payment. This could not be so, because if he was planting too large a crop and we assume that the price of his crop is equal to the marginal cost of the profitable amount of output, as it would be under perfect competition, he would still be unprofitable since the cattle-raiser only pays him the market amount for the damaged crop. In fact crops may be underplanted if the value of the undamaged crops will not cover the total cost of cultivating a particular tract of land. If this is true it will be profitable for the farmer and the cattle-raiser to strike a bargain to keep that tract uncultivated.

It is obvious, therefore, that if the cattle-raiser is liable for damages to the farmer's crop caused by his cattle and there are no transactions cost involved in bargaining, the loss in production in one are (crops) will be taken into account in the costs of another area (cattle-raising). This will make the allocation of resources optimal for the cattle-raiser. Since market transactions are

possible to secure the abandonment of cultivation when the amount of damage exceeds the rent on the land, where the rent is the total value of output on this land minus the value of the extra production that is possible if the factors of production were in their next best use, you don't get too large an employment of factors of production in farming or too small in the cattle-raising industry. If it were not possible to secure abandonment of cultivation through the market, the cattle-raiser would be paying a high damage payment and the factors of production in farming would be wasted, and fewer factors of production would be allocated to cattle-raising.

But by bargaining, the factors in farming could be released and used up to the value the farmer has given up, which is the rent, to keep the land uncultivated. The payment to the farmer would be less than that paid for damage if the land was cultivated, since we assumed that the damage was greater than the rent, thus the cattle-raiser would be better off. Therefore, by bargaining for the discontinuance of cultivation of a piece of land the factors are released to produce a positive output elsewhere, and the underallocation of resources to cattle-raising and the overallocation of resources to farming is remedied. Thus the allocation of resources is such that the value of production is maximized, and both parties have taken the harmful effect into account, the cattle-producer through higher costs and the farmer through less output.

Assume now that the cattleman is not liable for damages and that the pricing system is again costless. Coase shows that the allocation of resources is the same as in the case where the cattle-raiser is liable. Suppose that the cattleman is contemplating adding a fourth steer to his herd of three. This fourth steer will increase the annual damage inflicted on the wheat farmer from 30 to 45. Because the marginal increase in damages will be 15(=45-30), the farmer will be willing to pay the cattleman as much as 15 to bribe him to keep his herd size down to three. If the cattleman is aware of the farmer's willingness to bribe him, then he foregoes this payment if he decides to increase the herd. In other words, this 15 must be added into his marginal cost for

the purpose of calculating his profits on the herd of 4 steers. Indeed, these costs are foregone at each level of output. Thus, for the first steer, the wheat famer is willing to pay 10, the marginal value of damage done by that steer. Hence, when this foregone "bribe" is subtracted from the figures in the second column of Table 1, the profit becomes 90. Similarly, the farmer is willing to pay another 5 to prevent the cattleman from adding a second steer. Hence, the profit for a herd of 2 steers is really 150 less the value of marginal damages caused by the first and second steers 15(=10+5), which is 135. If this calculation is performed for every level of cattle output, the profit schedule obtained is identical to that of the fourth column and the cattleman will choose a herd size of 3 steers.

Thus, even if the cattleman is not liable for damages, knowledge of the cost he foregoes from a possible bribe by the farmer that is equal in amount to the sum of the marginal damage done at each level of production will cause him to act in exactly the same way as he would if he were liable for damages. The difference, of course, is that it is the farmer rather than the cattleman who is bearing the cost of reducing the herd size. The output of cattle will be the same whether or not the cattle producer is liable for damages inflicted on the wheat farmer. Thus, allocative efficiency is achieved irrespective of assignments for damages.

Our discussion so far is based on the assumption that there are no means which could eliminate damage. If there are means like fence between the adjoining plots of land, and if these means were less expensive than the damage payment one is liable for he would undertake the preventive measures.

Suppose the annual cost of erecting a fence between the two land plots is 35. Recall that the equilibrium (maximum profit) herd size was three when the cattleman was liable for damages inflicted upon the farmer. Consider again the cattleman's decision concerning the addition of a fourth steer to his herd. Referring to Table 1, it appears that his profits, inclusive of the costs of damage to the wheat, fall from 145 to 140 without the fence. With the fence,

Table 2

Size of cattle herd	Annual profits based on private costs	Annual cost of fence	Annual profits after deducing cost of fence
1	100	35	65
2	150	35	115
3	175	35	140
4	185*	35	150*
5	180	35	145
6	175	35	140

*Maximum profits.

his profits rise from 145 to 150(=185-35). Table 2 gives his profits at each level of output when the fence is installed.

It is clear that if the cost of the fence is in fact 35 per year, then the cattleman will elect to build it because by doing so he can increase his maximum profits by 5 per year. Under these conditions, he choose a herd size of four and earns annual profits of 150. But suppose the annual cost of the fence is 150? In that case, the cattleman cannot increase his profits by building the fence and will elect to continue paying damages to the farmer while working with a herd size of three. To understand why this is so, subsitute 50 in the third column of Table 2 and calculate the cattle profits for each size of herd.

If the cattleman is not liable for damage and the cost of building the fence is 35, then the same result is obtained, but in this case, the cost of the fence will be borne by the farmer. The farmer will elect to build the fence when the cattle producer increases his herd size to four rather than pay the cattleman the amount of 45. This lowers the cattleman's cost for adding the fourth steer and results in profits of 150. If he were to add a fifth steer, his profits would fall to 145, as shown in Table 2.

3. Graphic Analysis

Gifford [19] and DeSerpa [14] present a graphic representation of the Coase theorem, one which, though simple, helps in understanding of the theorem. Our diagrammatic discussion of the Coase theorem is based on that of DeSerpa.

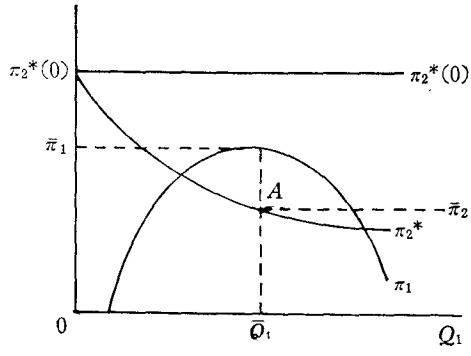


Figure 2

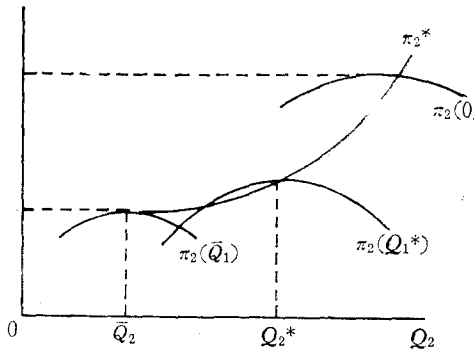


Figure 3

His model assumes no bargaining costs or indirect distributional effects, and involves two perfectly competitive firms of a single output Q_1, and Q_2, both maximizing their respective profits π_1 and π_2. Firm 1 adversely affects firm 2's costs of production through an externality which it produces.

Figure 2 shows firm 1's profit curve and shows that in the absence of liability rules or any bargaining with firm 2 it will produce $\bar{Q}_1$ so as to maximize profits. Firm 2's profit curve is more complicated since it will face a different curve for every output level of firm 1 as shown in Figure 3. The curves in Figure 3 labeled $\pi_2(0)$, $\pi_2(Q_1^*)$ and $\pi_2(\bar{Q}_1)$ represent the relevant profit curves when firm one is producing output at the level shown in the parentheses. In the absence of bargaining, firm 2 faces the $\pi_2(\bar{Q}_1)$ profit curve since firm 1 will produce $\bar{Q}_1$ units of output, and firm 2's maximum profits is $\bar{\pi}_2$ while firm 1's is $\bar{\pi}_1$, The π_2^* curve is the locus of the maximum profit point for each level of output of firm 1, and it has been redrawn on Figure 2.

If we first assume that firm 1 is not liable for damages, then firm 2 must bribe firm 1 to a lower level of output, and the maximum amount he would be willing to pay is the difference in his profits due to firm 1's lower output; this difference is represented by curve B in Figure 4. The vertical sum of the B curve and π_1 curve shows how much profit plus bribe firm 1 can obtain at each lower output level, and this can be no less than $\bar{\pi}_1$, his profit at output $\bar{Q}_1$, or he

Figure 4

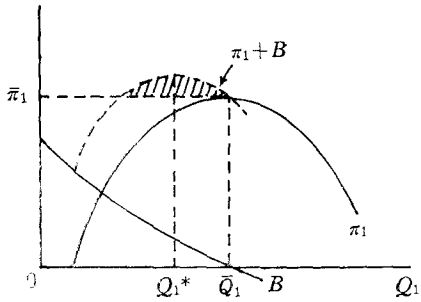
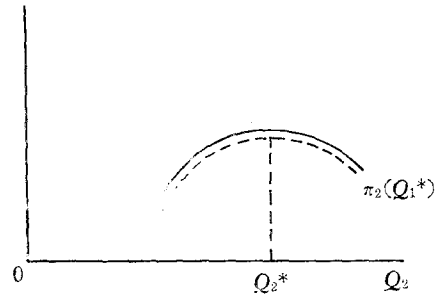


Figure 5



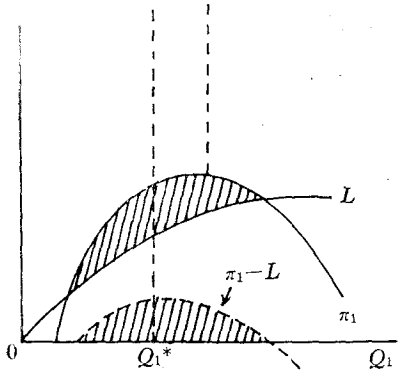


Figure 6

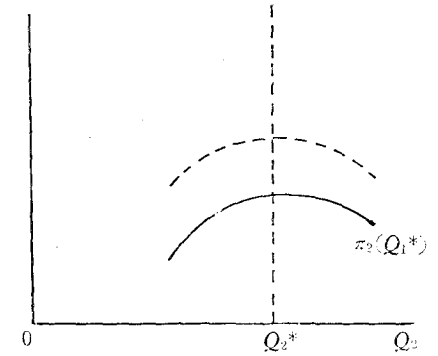


Figure 7

won't change his output level. The shaded area shows the area where a bargain could be struck, since firm 1 will be at least maintaining $\bar{\pi}_1$. The optimal behavior for firm 1 is to maximize the sum of profits and bribes which means he will produce Q_1^* units of output. This output level then determines firm 2's profit curve, as shown in Figure 5. The curve has been shifted downward by the amount of the bribe, and firm 2's optimal output level is Q_2^*.

Now if we assume that firm 1 is liable for the damages caused to firm 2, we can say that firm 2 is entitled to the profit it would achieve in the absence of any activity on firm 1's part, $\pi_2(0)$. So at any level of output of firm 1, firm 2 will have to be compensated for its loss in profit, up to $\pi_2(0)$. In Figure 6, curve L represents a liability curve which shows the minimum compensation that must be paid to firm 2 for each level of firm 1's output. This curve represents a cost to firm 1, so firm 1's optimal behavior is to maximize its profits

above this cost curve; this will occur at Q_1^* output.

The optimum levels of output are the same in both cases, with liability rules and without. In Figure 4 equilibrium is obtained by equating the sum of the slopes of π_1 and B to zero $(\pi_1' + B' = 0)$. In Figure 5, the same point was obtained by equating the slopes of π_1 and L where the slope of L is equal to the negative slope of B $(L' = -B')$. So, it can be seen that the point Q_1^* in Figure 4 is the same as Q_1^* in Figure 6. With Q_1^* fixed, firm 2's relevant profit curve is now determined and is shown in Figure 7. The curve has been shifted upwards by the amount of the compensation payment, and once again firm 2's optimal output is at Q_2^*. This diagrammatic approach has shown then, what Coase presented in the cattle-raiser and farmer example, that the efficient allocation of resources is invariant to the initial legal position.

IV. Controversies on the Coase Theorem

Since the original article by R. Coase appeared in 1960 there has been tremendous controversy over whether his theory is valid or not. The Coase theorem has been criticized on many grounds, including the existence of differences in the bargaining process, relevance of transaction costs, insufficient analysis of the bargaining process, and equity considerations. Some writers have attempted to specify the conditions under which resource allocation would be both socially efficient and invariant under different liability rules in the presence of externality. Others have attempted to show that for various reasons the theorem is not valid. Arguments for and against the Coase theorem over the last twenty years or so have helped to rectify problems associated with the theoretical construct and the policy prescriptions in both the Pigovian tradition and the Coasian analysis.

Controversies surrounding the Coase theorem can be conveniently divided into three categories. The first is related to the question as to whether the assumptions underlying the Coase theorem are realistic and the solutions are

workable.[5] The second group of controversies questions whether the model is valid or not, even in the context of Coase's own assumptions. The third controversy has something to do with the ethical symmetry implied in Coasian claims. In what follows we examine each of the above-mentioned issues in turn, with emphasis on the findings brought to light by the heated debates between the Pigovian and the Coasian camps.

1. Underlying Assumptions: Zero Transaction Cost

One of the most vulnerable aspects of the Coase theorem is the assumption that the price system operates without cost, that is, the assumption of zero transaction cost. Most difficulties with the Coase theorem have stemmed from different conceptions of what is implied by zero transaction cost, and much of the confusion on externalities and legal rules has arisen because writers in the field have not made clear their assumptions on transaction costs.

As our discussion in Section III and the literature on the Coase theorem show, the Coase theorem assumes that there are no transaction cost. Examples cited by Coase in his original article to show how voluntary bargaining leads to the efficient outcome in the presence of externalities deal with a two party world, as in the cattle rancher and wheat farmer, the doctor and the confectioner, and so forth. In this simple world transaction costs can be assumed away.

Needless to say, in the real world externalities involve very large numbers of affected parties. For example, where the pollution of a river basin by hundreds of polluters has affected millions, it is inconceivable for all the concerned parties to get together and bargain privately. The effects of air pollution are

(5) As to the role assumptions play in theory construction, the following remark by Graaff [21] is quite suggestive:

"Whereas the normal way of testing a theory in positive economics is to test its conclusions, the normal way of testing a welfare proposition is to test its assumptions. The significance of this should not be overlooked. In positive economics we often simplify our assumptions as cavalierly as we please, being confident in the knowledge that their appropriateness will be tested when we come to apply the conclusions inherent in them to our observations of the world about us. In welfare economics we can entertain no such confidence. The result is that our assumptions must be scrutinized with care and thoroughness. Each must stand on its own feet. We cannot afford to simplify much." (p. 3)

even more diffuse. Baumol and Oates [4] have omitted the small-numbers case externalities from their analysis because they believe that the case is disproportionate to its importance for policy. For most meaningful cases, the transaction costs for an existing externality are not insignificant, as assumed in the Coase theorem.

If transaction costs are high, they will prevent the arrangement of a bargaining which would confer positive benefits in the absence of the transaction costs. A general consensus seems to exist that market internalization is least likely when the number of parties involved in the externality relationship is large. This justifies the argument for state intervention, quite contrary to the Coasian policy prescription.

Those who believe that realistic assumption underlying the theory should be a criterion of the validity of the theory in question can question the validity of the Coase theorem because the unrealistic assumption of zero transaction cost underlies the theorem. Coase [9] himself agrees with this conclusion when he says that:

> "While consideration of what would happen in a world of zero transaction cost can give us valuable insights, these insights are, in my view, without value except as steps on the way to the analysis of the real world of positive transaction costs." (p. 187)

Although the zero transaction cost assumption is constantly invoked by economists, its nature and content remain largely unexplored. The contribution of the Coase article is that it highlights the importance of transaction costs in bargaining in a market context.

What various critics of the Coasian world with no transaction cost have failed to realize is that such a world is inherently heuristic. The relevance of externalities lies in the fact that they indicate the presence of some transaction costs. For if there were no cost of transacting, then the potential Pareto improvement could be realized by costless bargaining between self-interested economic agents. Transaction costs are a necessary condition for the persistence of

unwanted effects from externalities for with zero transaction cost side effects will be internalized and will not negatively affect resource allocation.

Furthermore, the simultaneous existence of competition and of small numbers of externally affected and effecting parties is mutually inconsistent phenomenon. If the large numbers generally associated with competition are present there will exist the acknowledged prohibitive transaction costs. In the absence of such competition, however, market solutions are burdened with complex, game theoretic bargaining situations which involve a substantial likelihood of counterproductive (costly) activity and for which the achievement of efficient outcomes cannot be assured

In short, it is economic nonsense to talk about externalities in a zero transaction cost world.

2. The Validity of the Coase Theorem

The second type of controversy is to challenge the validity of the Coase theorem, even in the context of its own assumptions. In this regard we examine two issues: (1) whether the Coase theorem holds in the short run, especially under the conditions of nonseparable cost functions and strategic behavior and, (2) whether the short run results can be extended to the long run.

(1) The Coase Theorem in the Short Run

Since the original article by Ronald Coase appeared in 1960, there has been tremendous controversy over whether his theory was applicable in the short run or the long run. The short run controversy seems to have been relatively short lived as almost all writers now agree that under the assumption of zero transaction cost the allocation of resources will be invariant to any particular delimitation of property rights over an external effect.

Gifford and Stone [20] and Marchand and Russell [26], each with a mathematical analysis, proved and disproved respectively the short run validity of the Coase theorem. The Gifford and Stone paper deals with the maximization of profits for two firms, one the externality producer and the other the recipient firm, in which the bribe or the compensation payment appears as a

fixed cost or fixed revenue in the profit functions. They find that the Coase theorem is indeed validated by the analysis.

The Marchand and Russell do basically the same thing except instead of using the difference in profits as the basis for limits on bribing and compensating they use the difference between the actual costs incurred and those that would have occurred in the absence of externality. Their analysis indicates that in the case of nonseparable cost functions the levels of output depend upon the allocation of liability (thereby challenging Coase's symmetry results). They also conclude that the levels of output differ from the sociallic optimal output levels regardless of the liability assignment (challenging Coase's implications for efficient resource allocation). Their conclusion is that the Coase theorem is not valid, even abstracting from income effects and transaction costs, except in the case of additively separable cost function.[6]

In a comment to this article, Gifford and Stone demonstrate that by using foregone profits as the cost of damage for liability the theorem is valid. They feel that Marchand and Russell's mistake is in using a legal definition of liability by using actual costs imposed by the externality producer instead of the economic definition of liability which should use foregone profits.

One problem with the idea that the voluntary approach results in optimality is the problem of threats. It is axiomatic that good bargainers never disclose their bargaining limits, and this opens the way to threatening behavior.

Mumey [31] holds that, in the absence of liability rules, threat could be used to generate revenue, through bribery, by the externality producing firm. This, in turn, could lead to a possible misallocation of resources since incentives could exist for channeling resources into the invention of threatening actions or production processes. Thus Mumey feels that collective action would have to be taken to rule out such bargaining behavior.

Coase does not rule out strategic behavior but assumes that when it does occur it will be transitory and have no effect on the efficient allocation of resources in

(6) A function $f(x,y)$ is said to be separable if it can be written as $f(x,y)=g(x)+h(y)$.

the long-run. Since there are limits to how much of a bribe could be paid it would not affect the solution. In order to make the threat credible it might be necessary to carry at least part of it out, and since we would assume that the externality producer was operating efficiently before the change, any increase in output would undoubtedly lower profits, and he would thus be worse off.

One may conclude that the profit motive is too strong for a firm to actually carry out a threat and lose profits by so doing. It seems only reasonable that the receiving firm would also take this view and call the bluff. Therefore, threats would not be something that would continue since the cost of making them is not offset by any benefits.

(2) Extension to the Long Run

The real controversy around the Coase theorem seems to be over the long run applicability of the theorem, as most economists agree that the theorem is valid in the short run under the assumptions of no distributional effects and zero transaction cost. The battle lines have been drawn, but the differences between the two camps seem to be based on their different assumptions.

Arguing against the extension of the Coase theorem into the long run are Tybout, Schulze and d'Arge [37], and Dick [15]. The primary contention on this side is that, because in one case the polluter gets a bribe payment and in the other the recipient gets a compensation payment, long run profits are different for the two liability rules. Given perfect competition, the industry which receives the payment will have higher profits and thus attract entrants into the industry. The Schulze and d'Arge paper assumes that certain transaction costs are positive, in direct contradiction to Coase's assumption.

Arguing for the extension of the Coase theorem into the long run are Nutter [33], Frech [17], and Gifford and Stone [20]. All assume that there are economic rents being earned by a non-transferable factor of production which negates the difference in profits and thus the long run entry of firms.

The difference in assumptions is typified by the Tybout article and the reply to it by Frech. Tybout finds that total profits are different for the two firms

depending on whether bribery or compensation takes place. Frech writes that the difference in profits is due to Tybout neglecting the property right to control pollution of the environment, and therefore the rent that it should command. By including this rent as an opportunity cost to the firm which holds the property right, the polluter in the bribery case and the recipient in the compensation case, Frech is able to show that the profits are identical under either ownership situation.

Both sides of the controversy seem to have valid points, given their specific assumptions, so how do we reconcile the two opinions that the Coase theorem is or is not applicable in the long run? The resolution seems to have come in a recent article by Frech [18] in which a distinction is made between alternative liability rules and different assignments of property rights. He says that liability rules are legal rules which assign liability for damage caused by pollution to either the polluter or to the recipients. Property rights on the other hand give exclusive rights to the control of a resource. With these definitions in mind we can resolve the disparity of views between the two sides of the controversy.

In the Schulze and d'Arge, Tybout, and Dick articles the authors assume liability rules are being assigned. In this context, there is no rent that must be paid for the use of the resource (the air basin in the case of pollution). Each new entrant into the industry can expect to receive or pay out compensation or bribe payments, which will affect their decision to enter. In the case where the polluter is liable for damages, new recipient firms will enter the industry because they see the compensation payments as an augmenting revenue for profits. In the case where no one is liable new polluting firms will enter the industry to get profits plus bribery payments. Therefore, long run entry and exit of firms is affected and would result in a misallocation of resources, too few polluting firms and too many recipient firms in the liability case and just the opposite in the non-liability case. This whole result is based on the fact that exclusion from compensation or bribery is impossible for

entering firms. Therefore the Coase theorem does not hold in the long run under alternative liability rules.

If, on the other hand, property rights to the control of a resource, such as an air or water basin, are assigned the Coase theorem is valid in the long run. This is the position taken in the Nutter, Frech, and Gifford and Stone papers. The assignment of an exclusive property right to certain individuals or firms merely provides the firms holding the right with a rent to this factor of production. This rent is simply a windfall gain to the owner of the property right. Since no part of the property right can be obtained by entering firms except through purchase, the long run entry and exit of firms will not be affected. Thus the basic argument against the long run applicability of the Coase theorem is refuted, and the theorem is valid in the long run for differing assignments of property rights.

Although he is not explicit, we can claim that it is property rights that Coase bases his theory on. Part of his new approach is to look at externalities as factors of production and he says that factors of production are rights. Throughout his paper, Coase explicitly interchanges the words liability rules and property rights, and in a system, where the entry and exit of firms is not considered, the two expressions are equivalent. Therefore a resolution to the long run controversy has been reached.

3. Distributional Effects and Ethical Neutrality

One criticism of the invariance principle which is now generally recognized by Coasians and critics alike is that if there are income effects in the system, the Coase theorem does not hold. There are distributional effects that do depend on who is assigned the property right. The Coasian idea of allocational neutrality has been shown to have intrinsic problems of its own.

Arguing against the Coase theorem's validity, Schulze and d'Arge [37] give a clear summary of how resource allocation will be different, depending on the assignment of property rights:

"Since the profitability of firms determine entry (presumed to be costless), and since

the allocation of property rights with respect to an externality will affect relative profitability of emitters and receptors, it is clear that the structure of industry will not be invariant to the configuration of property rights." (p. 764)

The price system may, in principle, be capable of solving certain simple externality problems of allocation but, as always, the price system cannot deal with problems of equity. It should also be pointed out that the issue of equity in the assignment of property rights arises in every allocational decision, not only in the study of externalities.

To Coasians it makes no sense to separate polluter and victim since the situation is reciprocal: To allow externality will benefit A and harm B, to disallow externality will benefit B and harm A. The only criterion is the total social product under different arrangements. Ethical neutrality means that there is no preferred way to assign rights. The idea of ethical neutrality underlies the idea of allocational neutrality.

Even if one accepts the allocational neutrality of the Coase theorem, he can still question its ethical neutrality. The question is why should a polluter become wealthy just because he happens to be in a position to place involuntary burdens on others? The example of a thief trying to rob my house illustrates ethical asymmetries in terms of active and passive parties.[7] Would a Coasian try to stop the thief, in spite of the fact that in doing so he would harm the thief? And would a Coasian weight on an equal scale the potential loss the thief would suffer if prevented from his activity with the potential loss of the passive victim? Our present court system has already passed society's judgement on this issue.

V. Concluding Remarks

Before concluding our discussion, we would like to point out one important

(7) A distinction between the active and the passive party is due to John Stuart Mill, who argues that a person is free to take any action unless it harm another past a reasonably low limit.

qualification. That is the fact that our discussion of both the Coase theorem and the Pigovian tax-bounty prescription so far is based on the assumption that perfect competition prevails. It can be easily demonstrated that neither the Coasian solution of voluntary bargaining nor the Pigovian solution of taxation can be efficient if imperfect competition prevails. This is a very important qualification, inasmuch as imperfect competition appears to be the rule rather than the exception.

It is necessary to distinguish between the relevance of market structure for the emergence of externalities and the relevance of market structure for the application of theoretical results to policy. As Pearce [35] has demonstrated, the bargaining solution of the Coasian type is efficient only if perfect competition prevails. Only when the industry generating the external diseconomy is competitively organized can a Pigovian corrective tax be unambigously hailed as welfare-improving, even in the presence of all the other required conditions. Under monopolistic organization, the corrective tax may well lead to a reduction in welfare rather than an increase.

Coase's 1960 article has produced many important changes in the way economists look at the problem of external effects. This is the real value of the Coase theorem. Even though the primary emphasis in the literature on the Coase theorem has been on the validity of the theory, the primary implications of the Coase theorem are methodological in nature and the underlying logic or ideas. The real policy relevance of the theorem and much of the literature it has inspired lies not so much in showing that the market can produce optimal level of externalities production under ideal and unlikely circumstances but rather in illustrating the circumstances and ways in which externalities produce market failure, something that had previously been imperfectly understood.

Certainly, the Coase theorem cannot be valid in the real world because transaction costs are not zero. Still, the ideas and questions implicit in it are very useful. The major point of Coase's paper is to overturn the commonly held assumption that externalities always create market failure and that therefore

collective action is always desirable and necessary. By focusing on particular deficiencies in a system the previous analyses had tended to accept any solution that removed the external effect, without regard to whether or not the solution produces more harm than it was designed to correct. Coase advocates that each different social arrangement that is a potential solution to the problem of external effects should be viewed in total. The arrangements will undoubtedly affect not only the initial problem but other areas of the economic structure as well as social and political areas, and all of these effects should be looked at.

The presence of externalities creates a necessary, but not, in all cases, a sufficient condition for public sector allocational intervention. The public sector is one of the primary institutions which may take corrective action in order to improve resource allocation and social welfare. The Pigovian solution of the tax-subsidy scheme is correct if and only if the receptor's costs are higher than those of the polluter. Yet public action is not the only possible means of corrective action, as the Coase theorem demonstrates. What the Coase theorem implies is that the superiority of one mechanism over the other is one of degree rather than kind. Hence, there exists no *prima facie* case for collective action or particular assignments of liability, as conventional policy prescriptions might have us believe.

Coase feels that the concept of "factors of production" must be changed if the analyses of external effects are to produce real world results. His new approach is to view externalities as a factor of production. Factors of production are rights and as such involve costs to society. Such is the case with externalities, and we must weigh the costs and benefits of different social arrangement when trying to choose the optimal one that will internalize the external effect. The total effect of a choice of a social arrangement, including the costs to run the arrangement, must be the focus of any such analysis. If there is no social arrangement that will carry with it more benefits than costs it would be advisable to allow the external effects to continue;there is no reason to believe that it is always better to remove the harmful effect at any cost.

Market failure characterized by externalities should be deduced rather than assumed. Coase's work should be interpreted as a plea to evaluate each case on its own merits and as having developed a framework with which to perform such evaluations. Whether a contract, tax, subsidy, merger, or no action at all is the proper solution depends on empirical parameters that should be examined on the case-by-case basis.

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